Introduction to NASA Water Products

Rain, Snow, Soil Moisture, Ground Water, Evapotranspiration

NASA Remote Sensing Training
Norman, Oklahoma, June 19-20, 2012

ARSET

Applied Remote Sensing Training

A project of NASA Applied Sciences

Objective

To present an overview of NASA water resource products from satellites and models

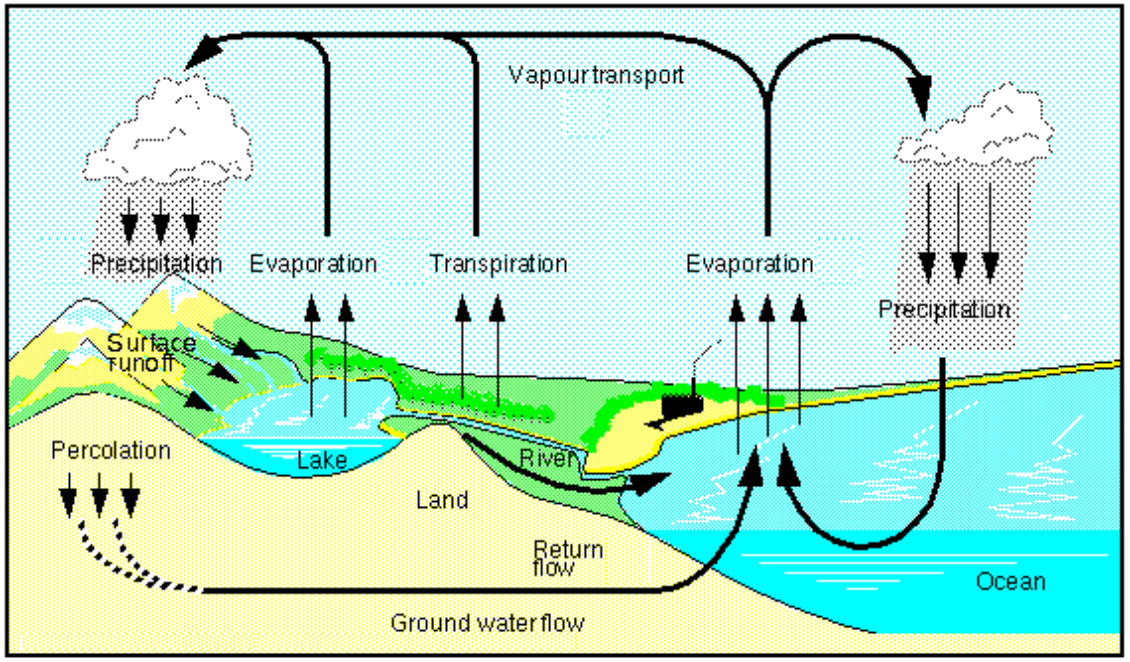
Part 1 :
Overview of Remote Sensing and Modeling Approaches

Part 2 :
Brief Description of Water Products from Various Sources: **Rain, Snow, Soil Moisture, Ground Water, ET**

NASA Applied Sciences Program
Water Resources site: http://wmp.gsfc.nasa.gov/

NASA Water Products

- Rain
- Snow/Ice
- Water Vapor
- Clouds
- Soil Moisture
- Ground Water
- Snow/Ice
- Rain, Clouds, Water Vapor
- Soil Moisture
- Evaporation/Transpiration
- Run off



Courtesy Erich Roeckner, Max Planck Institute for Meteorology

Water Cycle Components

Products in red - derived from satellite measurements

Products in blue - derived from atmospheric/land surface models in which satellite measurements are assimilated

NASA Water Products

	Units
• Rain:	
Rain Rate at surface (amount of rainfall per unit area per unit of time)	mm/hour
Accumulated Rain (rain amount over a day or a month)	mm
Vertical Precipitation Rate profile (liquid and frozen rain rate at various levels in the atmosphere)	mm/hour
• Snow:	
Snowfall Rate (amount of snowfall per unit area per unit of time)	Kg/m^2/hour
Fractional Snow Cover Area	Fraction
Snow Depth	m
Snow Mass	Kg/m^2
Snow water Equivalent	Kg/m^2
• Soil Moisture:	
Top Soil Layer Wetness	Fraction
Soil Moisture	Kg/m^2
• Terrestrial Water:	
Column Equivalent of Water [ground water+soil moisture +surface water]	cm
• Evapotranspiration:	Kg/m^2

NASA Rain Products

Source: Satellite and Surface-based measurements

Global Precipitation Climatology Project (GPCP) – based on multiple, US and global satellites

Tropical Rainfall measuring Mission (TRMM)

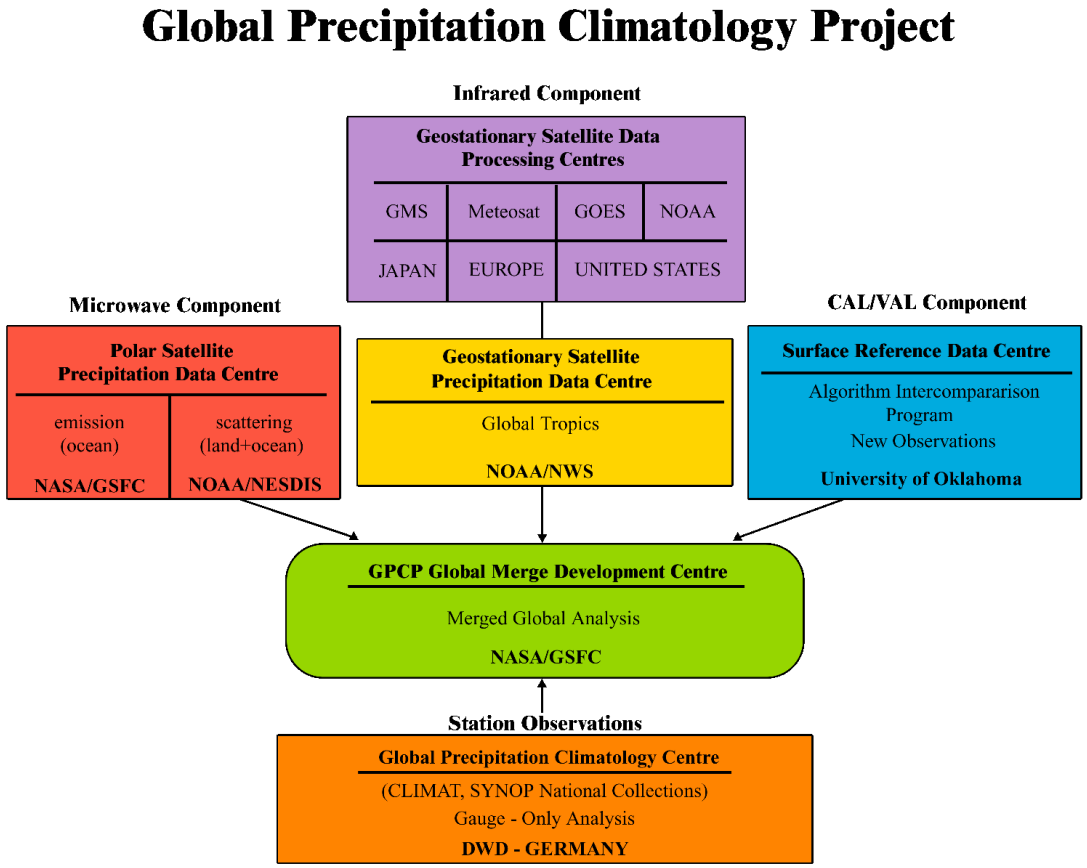
Source: Satellite and Surface Data Assimilated Models

Modern Era Retrospective-Analysis for Research and Applications (MERRA)

NASA Rain Products

GPCP

Data from over 6,000 rain gauge stations, and satellite geostationary and low-orbit infrared, passive microwave, and sounding observations have been merged to estimate monthly rainfall.



NASA Rain Products

TRMM

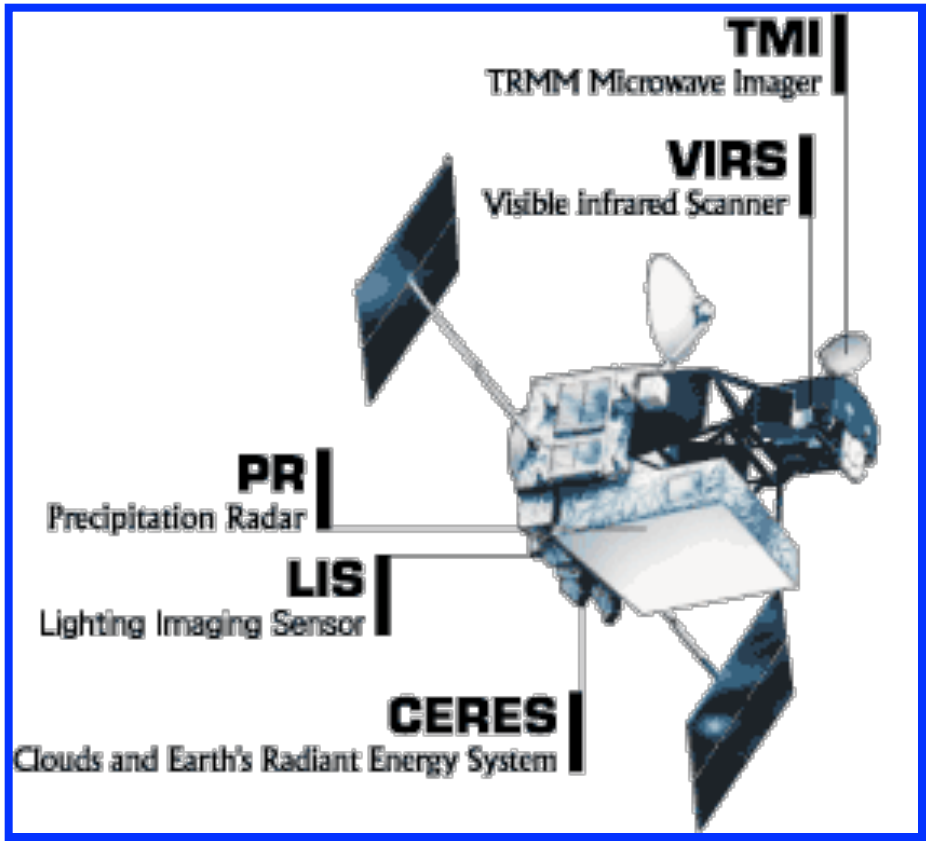
TRMM Instruments: infrared, visible, active and passive microwave

Precipitation Radar (**PR**)
(First rainfall sensing radar in Space)

TRMM Microwave Imager (**TMI**)

Visible and Infrared Scanner (**VIRS**)

TRMM merged product combines measurements from all instruments and other satellites along with rain gauge data



NASA Snow, Soil Moisture, and Evapotranspiration (ET) Products

Source: Satellites

Terra/MODIS -- snow/ice and ET

Aqua/MODIS -- snow/ice, ET
Aqua/AMSR-E – snow/ice, soil moisture

Source: Satellite and Surface Data Assimilated Models

Modern Era Retrospective-Analysis for Research and Applications (MERRA)

Global Land Data Assimilation System (GLDAS)

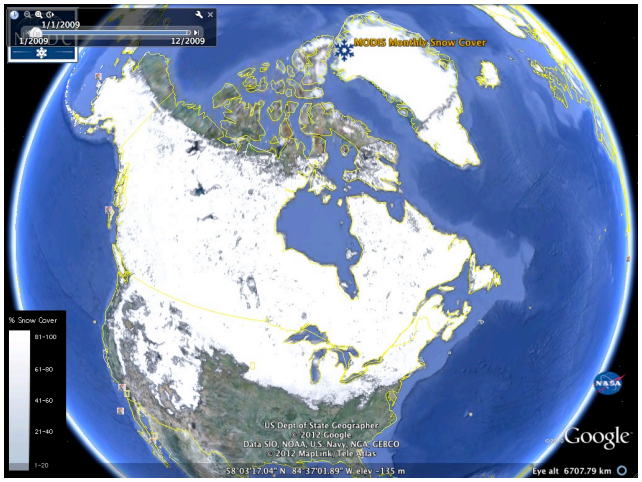
North American Land Data Assimilation System (NLDAS)

NASA Snow, Soil Moisture, and ET Products

Terra and Aqua

Instrument: MODerate Resolution Imaging Spectroradiometer **(MODIS)**

Products: snow, vegetation index (Used in ET calculations)

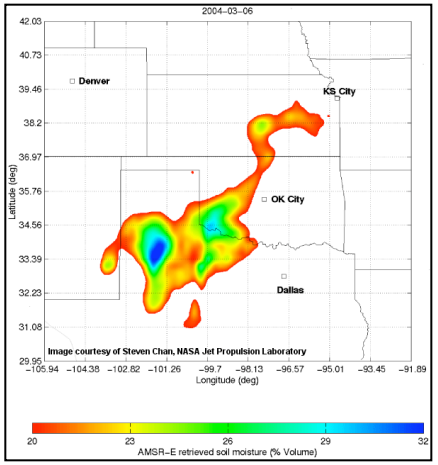


MODIS Snow Cover January 2009

Aqua

Instrument:
Advanced Microwave Scanning Radiometer for EOS (**AMSR-E)**

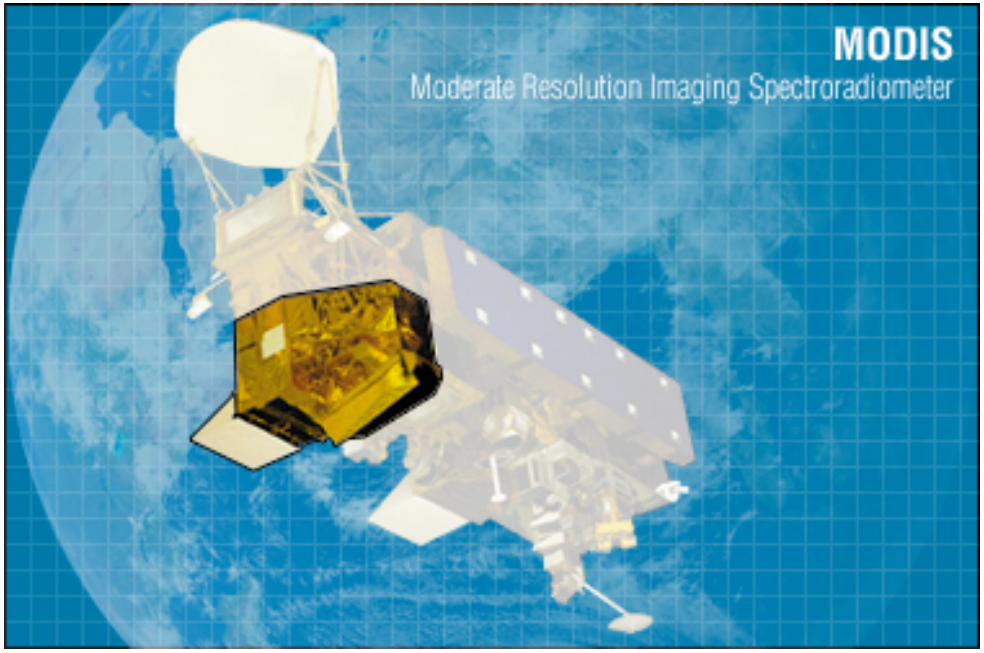
Products: snow water equivalent, soil moisture



Oklahoma Flood - Soil Moisture from AMSR-E (03 March 2004)

MODerate Resolution Imaging Spectroradiometer (MODIS)

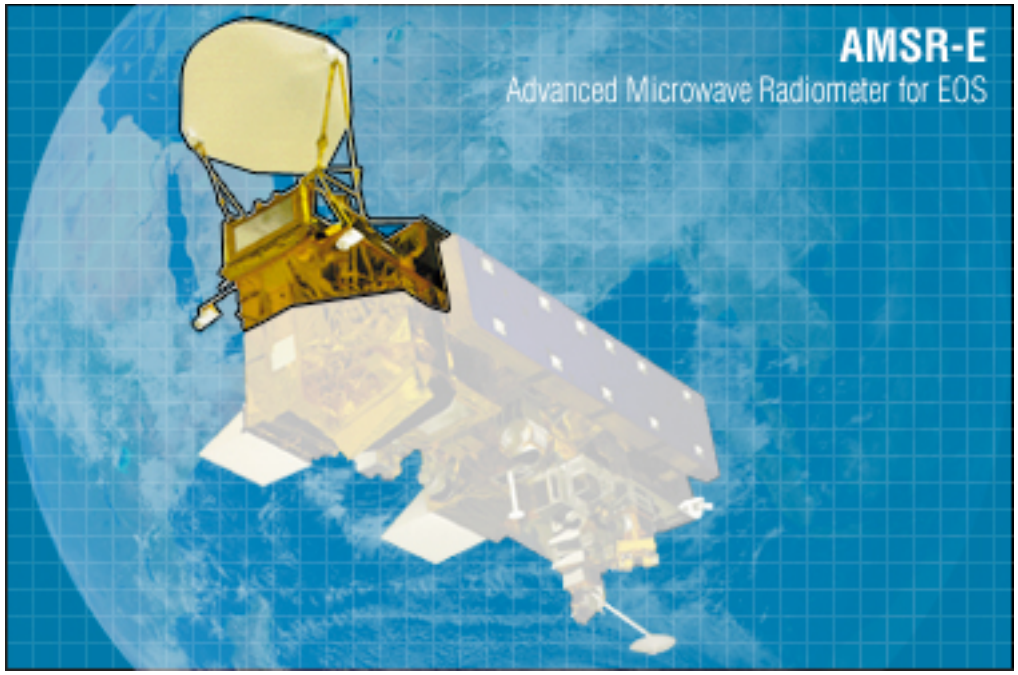
- 36 spectral bands ranging from 0.41 to 14.385 microns
- Many applications, including clouds, snow/ice, vegetation, ET, aerosol
- Available in various resolution (depends on product)



On-board Terra and Aqua satellites

Advanced Microwave Scanning Radiometer for EOS (AMSR-E)

- Provides snow/ice, soil moisture
- Twelve-channel, six-frequency, passive-microwave 6.925, 10.65, 18.7, 23.8, 36.5, and 89.0 GHz



On-board Aqua satellite

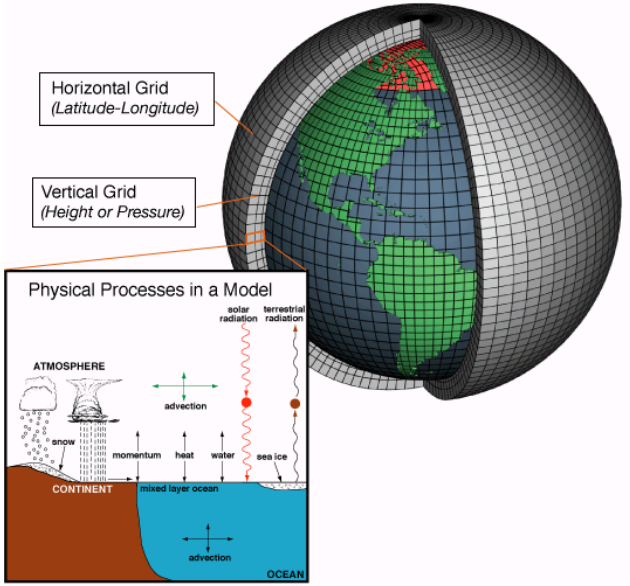
NASA Rain, Snow, Soil Moisture, and ET Products

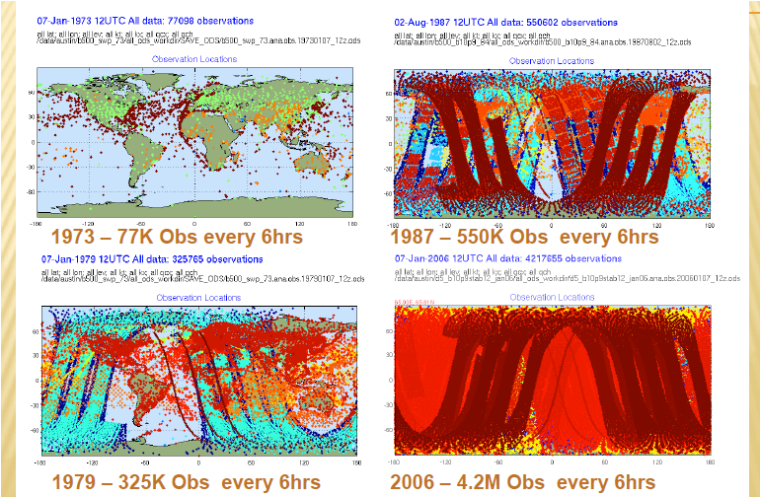
MERRA

Satellite and surface data are assimilated in NASA atmospheric model.

Rain products are calculated numerically based on physical processes represented in the model

Land Surface Model (LSM) forced by MERRA atmospheric analysis is used to get Soil Moisture, ET, and Snow products

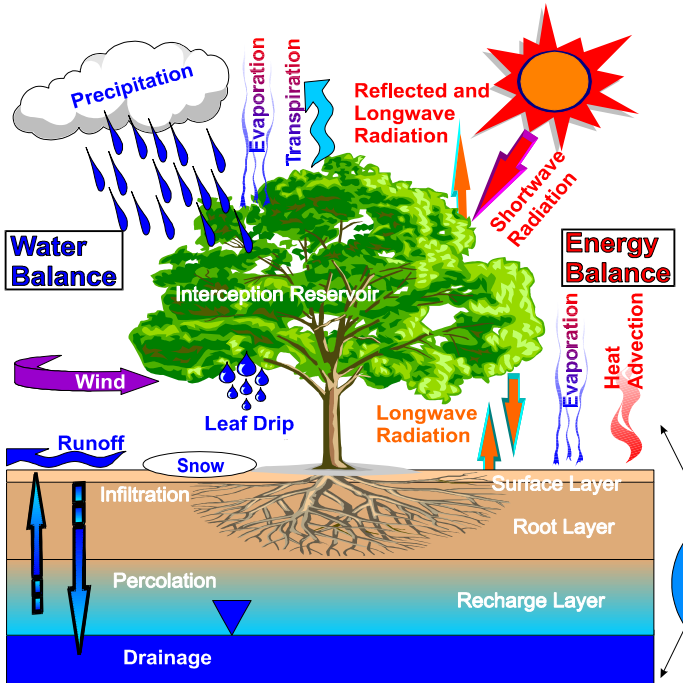




NASA Rain, Snow, Soil Moisture, and ET Products

GLDAS: Global, Satellite and surface-based observations of precipitation and downward radiation products, and analyses from atmospheric data assimilation systems are employed to force Land Surface Models (LSMs). Data assimilation techniques for incorporating satellite based hydrological products, including snow cover and water equivalent, soil moisture, surface temperature, and leaf area index.

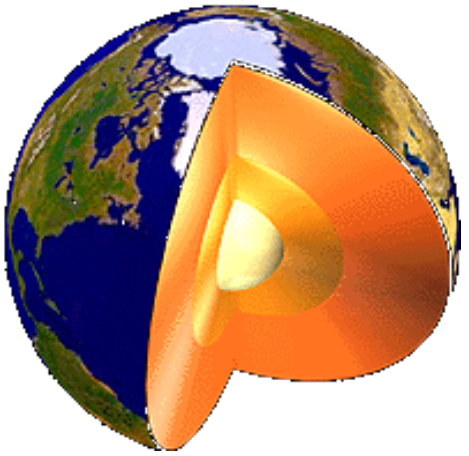
NLDAS: Over north America, forcing dataset from high-resolution surface gauge and radar based observed precipitation data, satellite and/ or model based surface radiative energy and surface meteorology drive LSMs to produce model outputs of surface fluxes, soil moisture, and snow cover.



LSM - SURFACE VEGETATION-ATMOSPHERE TRANSFER SCHEME

Courtesy Matt Rodell, NASA-GSFC

NASA Ground Water Product



Source: Satellite

The Gravity Recovery and Climate Experiment (GRACE)

GRACE measures monthly gravity field estimates
Which is affected by the amount of column of terrestrial water

Source: Satellite and Surface Data Assimilated Models

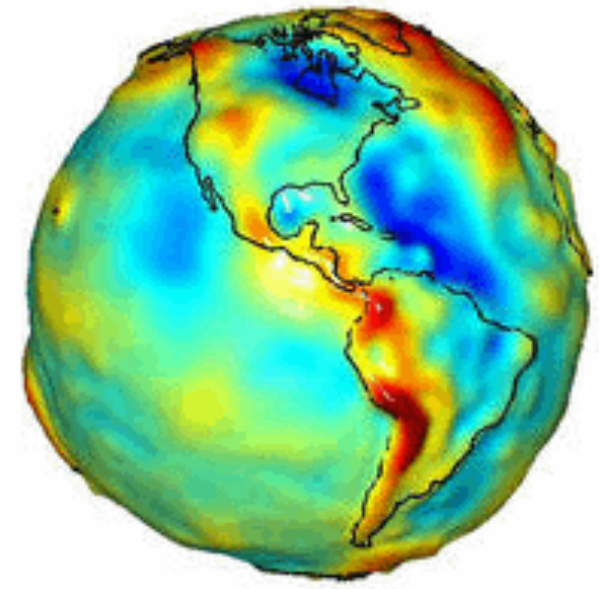
Global Land Data Assimilation System (GLDAS)

GLDAS provides surface and layer soil moisture, snow/ice, surface water

GRACE and GLDAS products together can provide ground water estimates

Gravity Recovery and Climate Experiment

Courtesy: Matt Rodell, NASA-GSFC



Science Goal: High resolution, mean and time variable gravity field mapping for Earth System Science applications

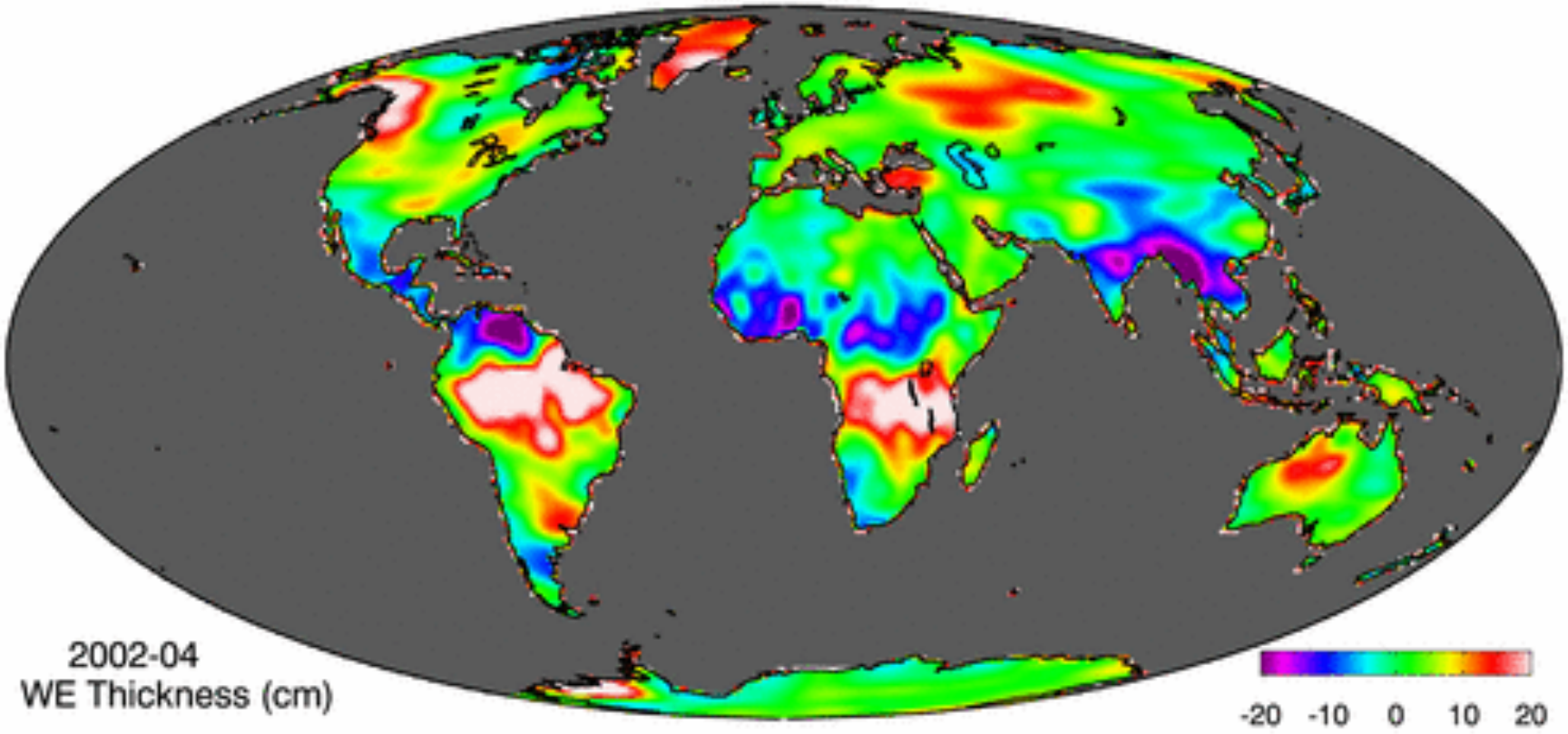
Instruments: Two identical satellites flying in tandem orbit, 215 km apart, ~485 km altitude

Key Measurements: Location and distance between two satellites tracked by GPS and high precision microwave ranging system

Key Result: Monthly variations in total terrestrial water storage (the sum of groundwater, soil moisture, snow, ice, and surface waters)

Terrestrial Water Storage Variations from GRACE

- Spatial resolution: 150,000 km² or coarser
- Monthly anomalies (deviations from the mean)
- Total column water: groundwater, soil moisture, snow, etc.
- http://gracetellus.jpl.nasa.gov/data/mass/



Courtesy: Matt Rodell, NASA-GSFC

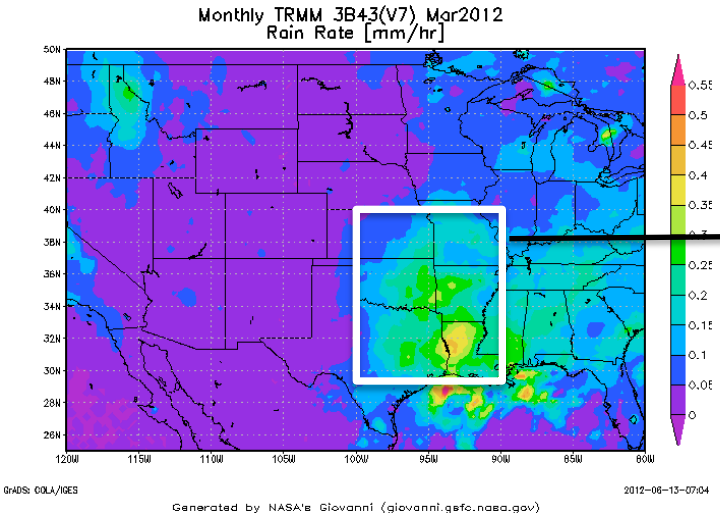
Rain Product Summary

Source/ product	Spatial Coverage	Spatial Resolution	Temporal Coverage	Temporal Resolution
GPCP: Rain Rate	Global	2.5°x2.5° 2.5°x2.5° 1°x1°	1979-present	Daily, 5-day, Monthly
TRMM and multi-satellite merged: Rain Rate Accumulated Rain	48°S-48° N	0.25°x0.25°	12/1997 to present	3-hourly, Daily, Monthly
MERRA: Rain Rate	Global	1.25°x1.25° 2/3°x1/2°	1979-present	Hourly, Monthly

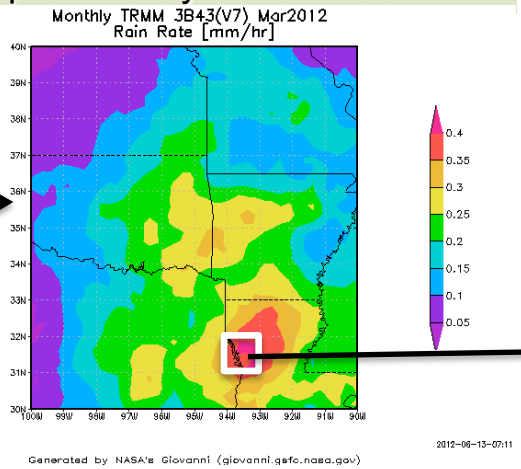
Snow, Soil Moisture, ET Products Summary

Source/product	Spatial Coverage	Spatial Resolution	Temporal Coverage	Temporal Resolution
Terra/Aqua – MODIS: Fractional snow cover and sea ice cover ET **Aqua/AMSR-E** Snow water equivalent Soil moisture	Global Global	500m, 0.05° (snow) 1 Km and 4 Km (sea ice) 1 Km 0.25°x0.25°	2-2000 to present/ 9-2002 to present 09-2002 to 2011	5 minutes (swath), daily, 8-days, monthly Daily, 8-day, Annual Monthly Twice Daily, Daily, 5-day
MERRA: Fractional snow cover, snow mass, snow depth, snow melt multi-layer soil moisture, ET	Global	2/3°x1/2°	1979-present	Monthly
GLDAS: Snow melt, snowfall rate, snow water equivalent, multi-layer soil moisture, ET	Global	1°x1°	1979-present and 1948- present (phase 2)	3-Hourly, Monthly
NLDAS: Snow melt, snowfall rate, snow water equivalent, multi-layer soil moisture, ET	North America	0.125°x0.125°	1979-present	Hourly

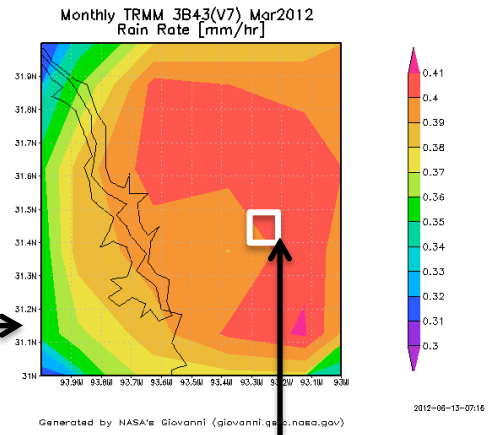
Spatial and Temporal Resolutions



Approximately 1000x1000 km^2

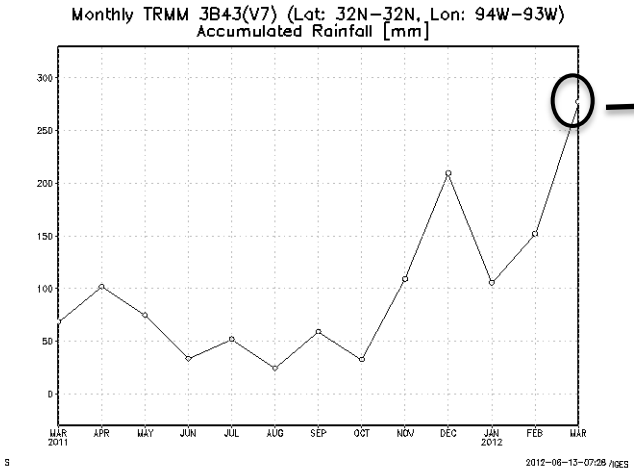


Approximately 100x100 km^2

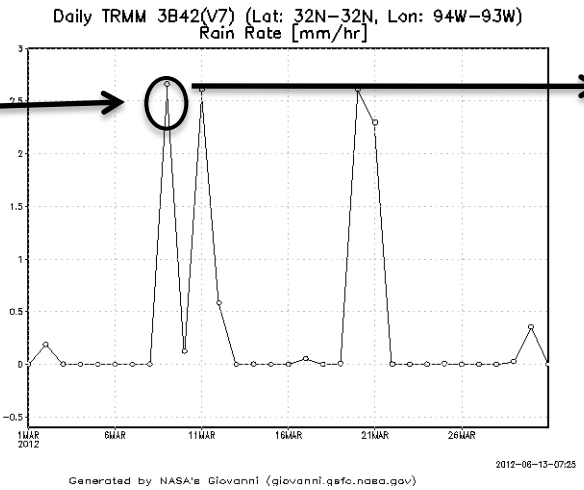


Approximately 25x25 km^2

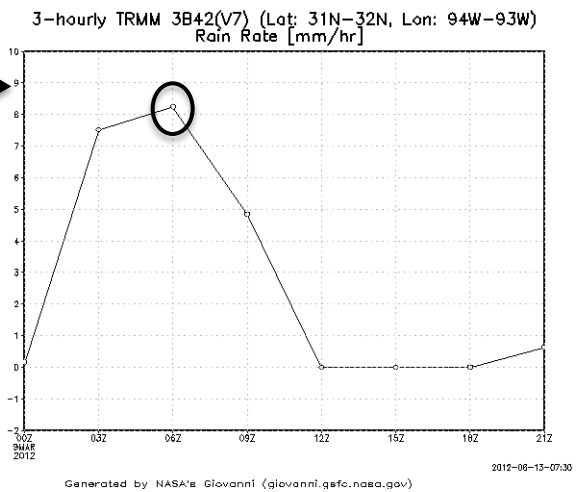
Monthly



Daily



3-hourly



Satellite Products

- There are multiple sources of the same products, with varying spatial/temporal resolutions and accuracies

- There are many assumptions and approximations in going from raw data to specific parameters such as rain amount, snow cover

- Product quality can range from excellent to poor depending on:
  - Instrument capabilities
  - Instrument calibration and performance
  - The algorithms used to interpret the data
  - Physical limitations

Model Products

There are multiple models, with varying spatial/temporal resolutions and accuracies

Modeling of hydrological processes is complex due to presence of water in gaseous, liquid, and solid forms in the earth-atmosphere system

Models use many approximations and assumptions in representing physical processes

Rigorous validation with observations and model-to-model inter comparisons are conducted to assess accuracy of model products

Web-tools, Data Access, Visualization

Giovanni (GES-DISC (Goddard Earth Sciences Data and Information Services Center) Interactive Online Visualization ANd aNalysis Infrastructure) http://disc.sci.gsfc.nasa.gov/giovanni/

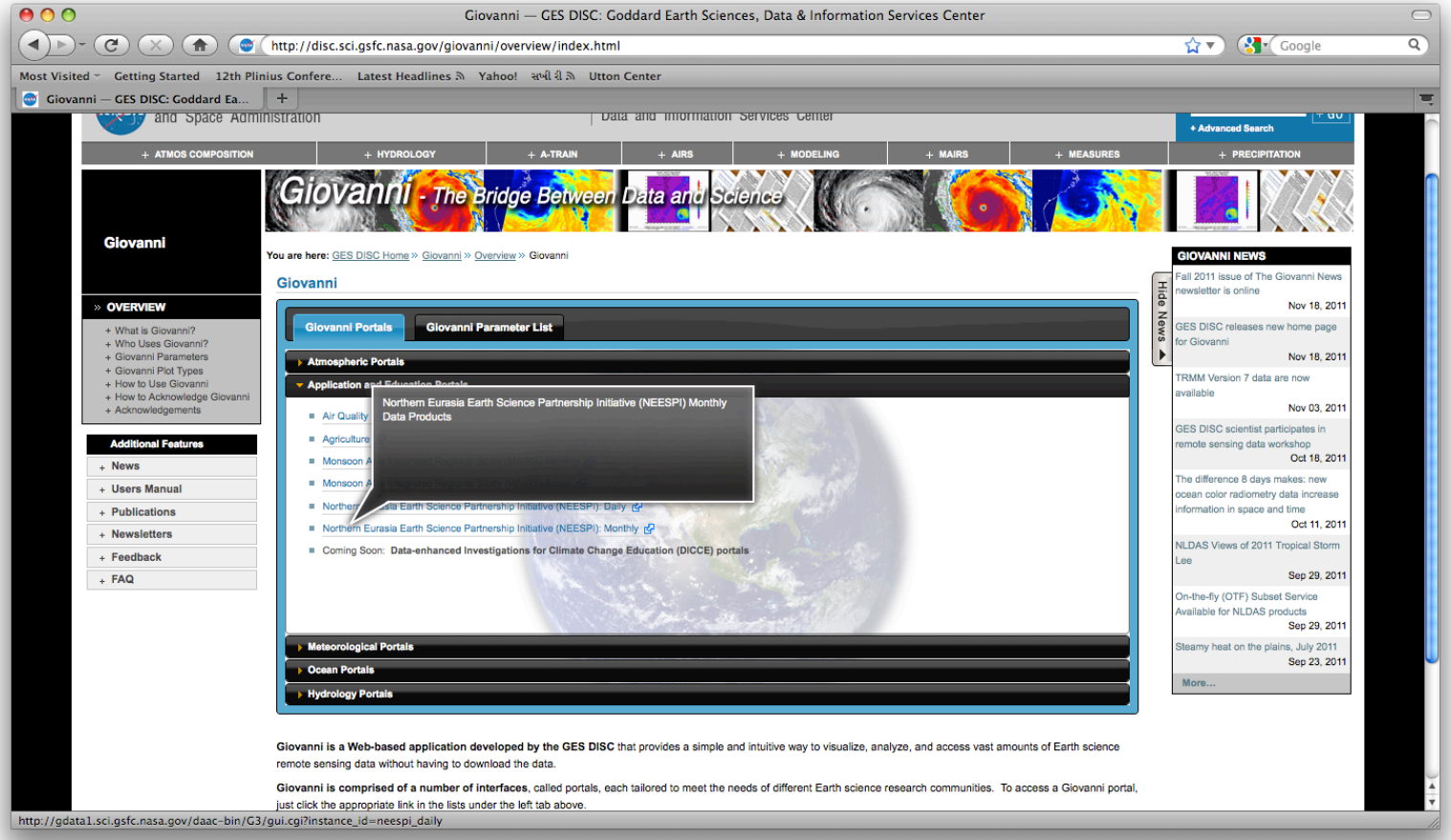
A Web-based portal that provides visualization, analyze, and access of **GPCP, TRMM, MERRA, GLDAS, NLDAS data without having to download the data**

Rain

Snow

Soil moisture

ET



NSIDC (National Snow and Ice Data Center)

http://www.nsidc.org/

A portal that distributes data products of snow, ice, glaciers, frozen ground, soil moisture

A tool to display MODIS snow/ice on Google Earth

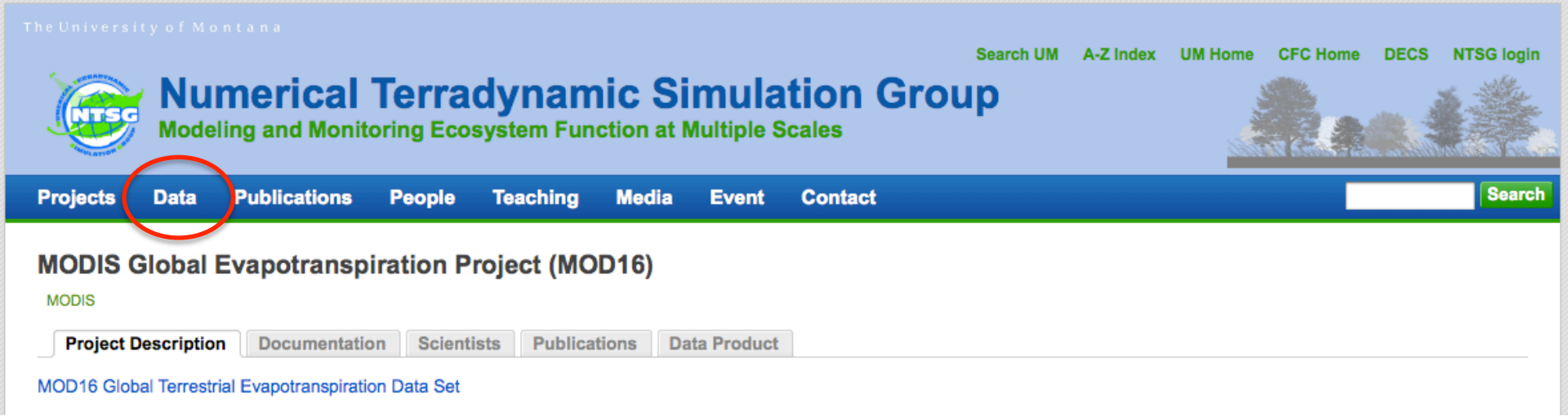
MODIS Snow/ice

AMSR-E snow water equivalent

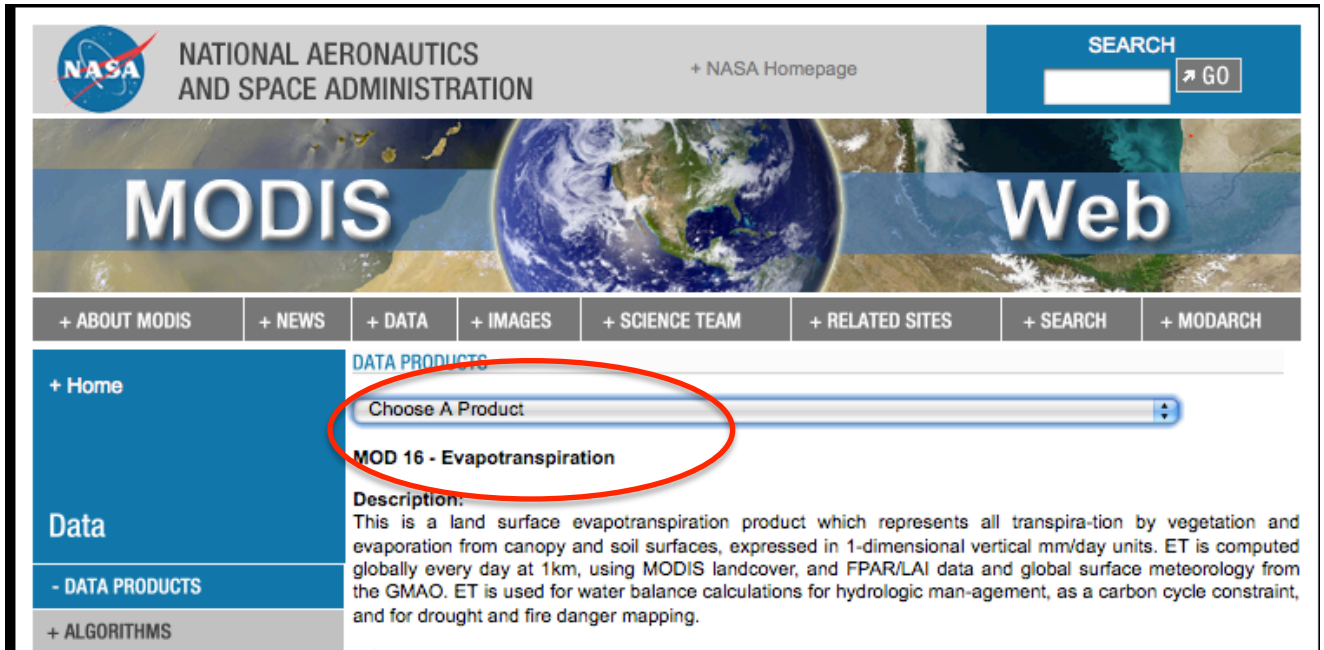
AMSR-E Soil moisture

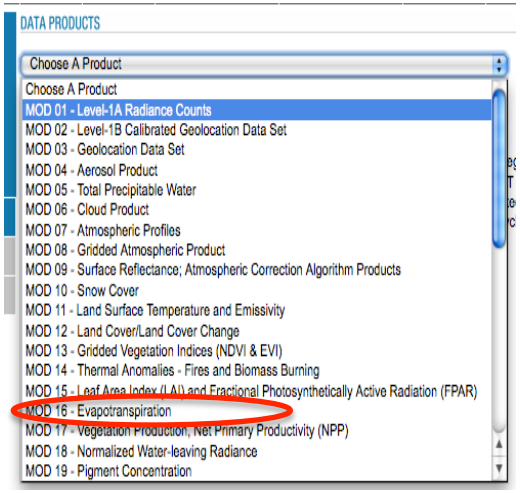
MODIS ET Product: MOD16

http://www.ntsg.umt.edu/project/mod16



http://modis.gsfc.nasa.gov/data/dataprod/dataproducts.php?MOD_NUMBER=16





Summary

- Multiple sources of NASA water products with different space-time coverage and resolutions
- Each product has its own strengths and limitations
- Product validation and accuracy are available from NASA researchers
- Appropriate products can be selected depending upon end-users' applications

NASA Applied Remote Sensing Training for Water Resource Management

http://water.gsfc.nasa.gov

- Find out about upcoming workshops on use of NASA Earth Science data sets and tools
- Access to training materials
-Links to other satellite resources

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Thank You!

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